4 Conservation Challenges Facing Seasonal Pools

Habitat loss and alteration associated with land development present the greatest challenges to the existence and health of seasonal pool ecosystems in the mid-Atlantic region. Seasonal pools, and the wildlife they support, are threatened by direct loss (e.g., through filling or draining), as well as by practices that degrade the pool: terrestrial habitat loss and fragmentation, biological introductions and removals, mosquito control practices, amphibian diseases, atmospheric deposition, and climate change.

4.1: Direct Loss of Seasonal Pools

The direct loss of seasonal pools due to draining, filling, and dredging in association with human activities presents a major threat to the persistence of seasonal pool-dependent biota. According to a U.S. Fish & Wildlife Service study, the following land development activities accounted for losses in freshwater wetlands in the time period between 1986 and 1997: 30% of losses were due to urban development, 26% of losses were due to agriculture, 23% of losses were due to silviculture, and 20% of losses were due to rural development (Dahl, 2000). Although seasonal pools, because of their small sizes and impermanent waters, were largely not accounted for in these statistics, it is likely that they are being lost in a similar manner.

Destruction of individual seasonal pools will eliminate populations of permanent residents, such as fairy shrimp, at those pools (Colburn, 2004). Also at risk are migratory residents of seasonal pools. Because of their limited dispersal abilities and site fidelity to breeding pools (Berven and Grudzien, 1990; Scott, 1994), adult pool-breeding amphibians are unlikely to make use of other pools in lieu of lost pools. In fact, adult amphibians may continue to return to the site of former (destroyed) pools throughout their lifetimes, rather than seeking out new breeding pools.

The loss of a seasonal pool may negatively impact other seasonal pool communities in the surrounding area. As seasonal pools and other wetlands become fewer in number, the distances between pools become greater, eventually exceeding the dispersal abilities of amphibians and reptiles (Gibbs, 1993; Semlitsch and Bodie, 1998; Gibbs, 2000). When seasonal pools are destroyed, the number of individuals that would have potentially dispersed to other pools is reduced (Gibbs, 1993; Semlitsch and Bodie, 1998), thus decreasing the rate of genetic exchange among populations and potentially inhibiting the rescue of locally declining or extinct populations (Laan and Verboom, 1990; Marsh and Trenham, 2001). For larger-bodied species that visit pools for food (e.g., waterfowl), these increased travel distances between pools may have important energetic implications (Gibbs, 2000).

4.2: Terrestrial Habitat Loss and Fragmentation

Urbanization, intensification of agriculture, increased density of roads, and timber harvesting have caused massive transformations of the landscape in the eastern United States. Changes in land-use in the mid-Atlantic region and their consequences for wildlife habitat, landscape connectivity (the extent to which the landscape facilitates wildlife movement), and hydrology present the largest challenges to seasonal pool conservation (Plate 4-1).

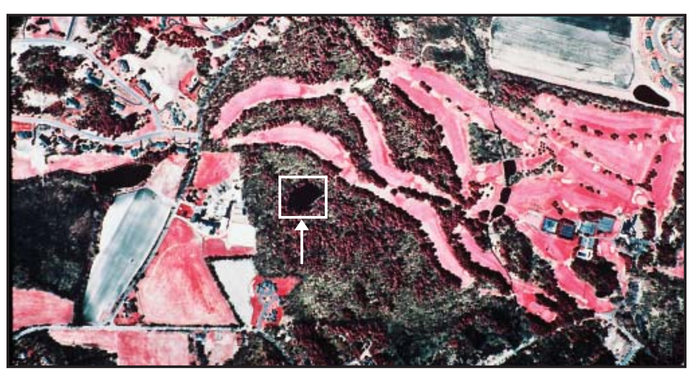

Photo: Massachusetts Department of Environmental Protection

Plate 4-1. Aerial view of landscape fragmentation. This color infrared aerial photograph shows a seasonal pool (dark circle marked by arrow) surrounded by human development.

Biological Effects of Habitat Loss and Fragmentation

Many of the wildlife species that use seasonal pools for breeding and feeding spend the majority of their lives in the forests and grasslands that are being lost to increasing human development. Thus, the conversion of terrestrial habitat directly threatens many members of the biological communities of seasonal pools by taking away their sustaining environment.

Land conversion also indirectly affects seasonal pool biological communities by restricting wildlife movements and facilitating invasion by disturbance-tolerant organisms. Land-use changes translate into fragmentation of the landscape, as forest patch to forest patch and forest patch to seasonal pool distances increase and the pathways of travel become more difficult for animals to traverse (Plate 4-1).

The conversion of natural habitats (forests and grasslands) to open land-uses, such as lawns, agricultural lands, and impervious surfaces (i.e., any surface that prevents water from infiltration into the soil, such as roads, buildings, and parking lots) creates barriers to movement and decreases landscape connectivity (Plate 4-2; Forman et al., 2003). Amphibians have difficulty traversing open landscapes due to higher temperatures and lower soil moisture (deMaynadier and Hunter, 1999; Rothermel and Semlitsch, 2002; Rothermel, 2004). Studies have documented pool-breeding amphibians' preference for forested habitat in the eastern United States. Spotted salamanders and wood frogs favor forests and avoid open-canopy habitats in their migrations (Semlitsch, 1981; Raymond and Hardy, 1991; Petranka et al., 1994; deMaynadier and Hunter, 1999; Rothermel and Semlitsch, 2002; Faccio, 2003). Mature forests provide moist microhabitats for amphibians: the thick leaf litter traps and stores moisture, the coarse woody debris provides cover and prevents soil drying, and a closed canopy with an understory offers shade and slows evaporation from the forest floor (Petranka et al., 1994). As juveniles and adults, pool-breeding amphibians are carnivorous, feeding on invertebrates such as earthworms, snails, slugs, spiders, crickets, beetles, and ants (Bishop, 1941; Petranka, 1998). They find this food in the leaf litter of forested areas beneath woody debris and below ground. Underground mammal burrows provide protection for mole salamanders from predators and freezing temperatures (Madison, 1997; Regosin et al., 2003a). Destruction or degradation of forested habitat as a result of poor forestry and land development practices negatively impact amphibian populations (Windmiller et al., 2006).

Photos: Bryan Windmiller

Plate 4-2. Terrestrial habitat fragmentation. Conversion of land near seasonal pools for (A) residential development, (B) golf courses, and other land uses will impact the faunal populations of these pools.

Fragmentation of the terrestrial landscape inhibits migrations of amphibians between the terrestrial habitat (where they spend greater than 90% of their juvenile and adult lives) and their breeding pools (Laan and Verboom, 1990; deMaynadier and Hunter, 1999; Rothermel and Semlitsch, 2002; Rothermel, 2004), decreasing or arresting their reproductive success. Decreased landscape connectivity may impede the dispersal of individuals between ponds, reducing rates of genetic exchange and potentially increasing the risk of local extinctions (Reh and Seitz, 1990; Laan and Verboom, 1990; Marsh and Trenham, 2001).

Roads, a pervasive and ever-increasing feature of the human-altered landscape, affect the survival and health of seasonal pool-dependent wildlife populations and the persistence of seasonal pools. Roads are a major source of fatalities (both directly as road kill and indirectly due to increased vulnerability to predators) and present a formidable physical barrier to animal migrations (Gibbs and Shriver, 2005). Amphibians and reptiles that try to cross roads experience high traffic mortality, particularly during the mass seasonal migrations of frogs and salamanders in early spring. Traffic mortality may cause significant declines in amphibian populations (Plate 4-3; Fahrig et al., 1995; Gibbs and Shriver, 2005). Amphibians' small body size makes overcoming man-made obstacles such as levees, ditches, and curbed roads a slow and difficult venture (Gibbs, 1998). Their small size and slow speed also makes them very vulnerable to predation when they are physically exposed due to the human-altered landscape (Gibbs, 1998; Rothermel, 2004).

Photos: James P. Gibbs

Plate 4-3. Spotted salamander roadkill. Particularly where roads separate seasonal pools from their terrestrial habitat, road mortality is a serious threat to amphibian populations.

The loss of reproductively-mature amphibians killed en route to breeding pools will have a significant impact on the population due to the additional loss of all of their potential future offspring (Dodd and Smith, 2003). The negative ecological effects of road construction on wetland biodiversity are cumulative over time (Findlay and Bourdages, 2000). The loss of amphibian and reptile species as a result of road construction may take an average of eight years to detect, and the full effects may not become apparent for decades (Findlay and Bourdages, 2000). When a threshold of road mortality has been crossed, populations may go into rapid decline and eventually become locally extinct (Gibbs and Shriver, 2005). Watershed and ecological impacts of roads on seasonal pools, such as altered wetland hydrology, road salt pollution, and reduced amphibian habitat and movement, may extend 984 ft (300 m) or more in each direction from a road edge (Forman and Deblinger, 2000). For example, the presence of tiger salamanders is negatively associated with the cumulative length of paved roads within 3281 ft (1 km) of their breeding pools (Porej et al., 2004).

The extent and pattern of terrestrial habitat degradation and loss that seasonal pool-dependent animals can tolerate without experiencing population declines and local extinctions depends upon the characteristics of the species and local conditions (Fahrig, 2002; Homan et al., 2004). Amount of forest cover, length and density of roads, and the degree of wetland isolation (distance to nearest wetland neighbor) have been shown to be among the most important predictors of amphibian species richness (Lehtinen et al., 1999; Porej et al., 2004; Herrmann et al., 2005).

Physical Effects of Habitat Loss and Fragmentation

Land transformations in seasonal pools' watersheds may directly affect the physical properties of seasonal pools in a variety of ways. These may include altered water chemistry, altered water regime (decreased or increased hydroperiods and higher or lower water levels), temporal variation in hydrology, altered water temperature, and increased sedimentation or erosion. Physical impacts to the seasonal pool due to land-use change, in turn, affect the biological community. Land-use practices in the watershed may alter the distribution of pool hydroperiods, either by a change in the amount and timing of water inputs to the pool or a change in the canopy cover. Surface water run-off to pools in impacted watersheds will have elevated temperatures due to the elimination of overhanging canopy and the path of water flow along heated impervious surfaces (Schueler, 1994).

Roads act as conduits for pollution, channeling fast-moving run-off that can contain car by-products, road salts, sediments, lawn applications, and other chemicals (Jones et al., 1992; Jones and Sroka, 1997). Increasing impervious surface area in a watershed potentially adds to the amount of non-point source pollution entering freshwater systems, including nutrients and chemicals (Wernick et al., 1998; Sonoda et al., 2001). Roadside seasonal pools have higher specific conductance and higher sodium and chloride levels compared to woodland seasonal pools away from roads (Turtle, 2000). Land cover change can also modify the quantity and type of sediment input into freshwater bodies (Jones et al., 2001). Pollution may affect seasonal pools disproportionately more than other aquatic habitats, such as rivers and lakes, because of the pools' small size and isolation from other water bodies. In late spring and summer, evaporation may result in very high concentrations of ions or toxins in the remaining seasonal pool water. Also, seasonal pools are filled partially or entirely by precipitation, runoff, and snowmelt that have undergone little to no buffering by the soil (Gascon and Planas, 1986; Wyman, 1990; Whigham and Jordan, 2003). Thus local events (such as nearby house or road construction) may have a great impact on the pools' water quality. Chemicals in the watershed, including pesticides from agricultural, residential, and industrial activities, may alter food web dynamics and decrease populations of invertebrates or amphibians (Boone and Bridges, 2003). Proximity to human development also increases the risk of pollution of pools by illegal dumping (Plate 4-4).

Photo: Michael S. Hayslett

Plate 4-4. Garbage fills this seasonal pool. This pool in southern Virginia has been used as a trash dumping site.

4.3: Other Conservation Challenges

Biological Introductions and Removals

Seasonal pools may be dredged or impounded for conversion to permanent water, for use as farm ponds or stock tanks. Once the hydrology is altered from seasonal to permanent, predators such as bullfrogs and fish may invade the pool and increase predation pressure on seasonal pool-dependent animals. Purposeful introductions of fish to seasonal pools for recreational fishing and/or mosquito control may also occur, which will likely have negative impacts on indigenous species of amphibians (Thompson et al., 1980; Hecnar and M'Closkey, 1997; Kiesecker, 2003; Colburn, 2004). For example, bluegill sunfish (*Lepomis macrochirus*) stocked in a Shenandoah Valley sinkhole pond may be responsible for declines in eastern tiger salamander populations (Buhlmann et al., 1999; Buhlmann and Mitchell, 2000).

Seasonal pool-dependent amphibians are collected as adults for consumption or laboratory use, or as larvae for use as fishing bait. According to a survey of fourteen scientific products suppliers, nine suppliers offer species of mole salamanders for sale for educational purposes (Jensen and Camp, 2003). The majority of these animals are likely captured in or around wetlands and seasonal pools, rather than being captive-bred (Jensen and Camp, 2003). Eastern tiger salamander larvae are sold in baitshops as "water dogs" (Jensen and Camp, 2003). The cumulative impact of collection of seasonal pool-dependent fauna is unknown in the mid-Atlantic region.

Mosquito Control Practices

Mosquito control practices may target seasonal pools. The most damaging practice employed for mosquito control is the filling or draining of seasonal pools. Other mosquito control methods include the application of surface films (oils added to ponded waters to suffocate mosquito larvae), chemical larvicides, and biological control agents. The effects of these mosquito control practices on seasonal pool food webs and pool-breeding amphibian eggs, larvae, and adults have not been extensively studied (Colburn, 2004). However, it is known that these control methods may impact groups of animals other than mosquito larvae and negative effects may take two years or longer to observe (Templeton and Laufer, 1983; Hershey et al., 1998). Control agents that reduce population sizes of plankton and invertebrates may, in turn, affect pool-breeding amphibians by reducing their food supply (Boone and Bridges, 2003). Additionally, the interaction of mosquito control techniques with other anthropogenic stressors may negatively impact the seasonal pool community (Boone and Bridges, 2003).

Amphibian Diseases

Another threat posed to seasonal pool-dependent amphibians is disease. Recent mortality events and increased susceptibility to diseases may be partially the result of reduced immune function from increased stress associated with habitat degradation (Blaustein and Kiesecker, 2002). Chytrid fungus (*Batrachochytrium dentrobatidis*) and ranaviruses can cause mass mortality in amphibian larvae, metamorphosing individuals, juveniles, and adults. These diseases may be transported by field equipment, fishing gear, or introduction of invasive species (Semlitsch, 2000; Carey et al., 2003). Ichthyophonus fungus and ranavirus infections have caused deaths of wood frog larvae and recently metamorphosed individuals, and ranavirus has caused deaths of spotted salamander larvae in seasonal pools in the mid-Atlantic region (D.E. Green, pers. comm.). For field work practices that minimize the spread of these diseases, refer to Appendix B.

Atmospheric Deposition

Atmospheric deposition may impact the water chemistry of seasonal pools to a greater extent than other aquatic habitats because many pools are primarily filled by precipitation and surface run-off (Gascon and Planas, 1986; Wyman, 1990). Acidification of pools through acid deposition does not have straightforward impacts on pool biological communities and may differ according to characteristics of the pool. Some studies show negative impacts of low pH on amphibian reproductive success (e.g., Pough, 1976; Gascon and Planas, 1986; Sadinski and Dunson, 1992) whereas others show no measurable impacts (e.g., Cook, 1983; Albers and Prouty, 1987). However, acidification elevates and makes more soluble and hence more bioavailable concentrations of metals in seasonal pool waters. High levels of metals, such as aluminum, copper, iron, lead, silicon, and zinc, may reduce hatching success of amphibian eggs, reduce larval survival, and increase the prevalence of amphibian deformities (Albers and Prouty, 1987; Blem and Blem, 1989, 1991; Rowe and Dunson, 1993; Horne and Dunson, 1995; Jung and Jagoe, 1995). Acid precipitation and atmospheric deposition of metals from industrial and residential sources may act synergistically to affect seasonal pool communities.

Climate Change

Seasonal pools face uncertain impacts from the climate change projected to occur over the next century. In the mid-Atlantic region, air temperatures and average precipitation are projected to increase; however, precipitation events are predicted to be of higher intensity and more erratic in timing (U.S. EPA, 2001). These precipitation and temperature patterns have implications for hydroperiods and water temperatures of seasonal pools, which will, in turn, affect amphibian egg and larval survival (Brooks, 2004). Climate changes may also affect the seasonal timing of animal activity. There is evidence to suggest that the warming of the climate over the last century has affected the breeding patterns of amphibians in the northeastern United States (Gibbs and Breisch, 2001).